ME

Research Report

CONSTRUCTION AND INTERIM PERFORMANCE REPORT OF EXPERIMENTAL SALT ($NaCl$) STABILIZATION OF PLANT-MIXED, DENSE GRADED AGGREGATE (The Silver City-South Hill (KY 1879) Road in Butler County, HF-16-1093 A-C3)

KYP-56

by

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INTRODUCTION

For some time the Department has been interested in building-up and retaining thicknesses of granular base course on rural roads through the use of various stabilizing additives and(or) the use of light asphalt seals or surfacings (1, 2, 3, 4, 5, 6). These efforts more or less recognize that the "stage construction" concept is frustrated by weather and traffic errosion of unbound and exposed granular base material. Thus, the motive in experimenting with and in utilizing these treatments is to find economical and effective means by which a granular base can be built and retained until such time that a higher type bituminous surface can be constructed upon it.

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This report is an account of the construction and short term performance of the Department's recent experimentation with salt (sodium chloride) stabilization and light, bituminous (A-2) seal on a compacted, dense graded, limestone aggregate base. A copy of the Project Authorization is shown in the Appendix. The total cost of the project was estimated at $30,000.

The roadway selected for this experimentation was the Silver City-South Hill (KY 1879) Road, length-2.71 miles, in Butler County (see Fig. 1). The existing roadway surface was traffic-bound limestone, varying from 0 to 4 inches in thickness (Figs. 2 and 3). The average thickness of traffic-bound stone was approximately 1-1/4 inches. The overall condition of the roadway was adjudged to be good. The shape of the cross section was good and the existing grade appeared stable. However, the ditches were full in many of the cut sections. Laboratory test results on a sample of subgrade soil from the project are given in Table 1. The soil sample was taken on a section (Sta. 37+00) where there was very little traffic-bound stone.

A schematic diagram indicating the locations, course composition and thicknesses of the various test and control sections, as constructed, is shown in Fig. 4. The dense graded aggregate was supplied, plant-mixed, by the Gary Brothers Quarry in Butler County, at a price of $2.10 per ton at the quarry for both the salt-treated and non-treated material. The Maintenance Division supplied the salt at the DGA plant site. The

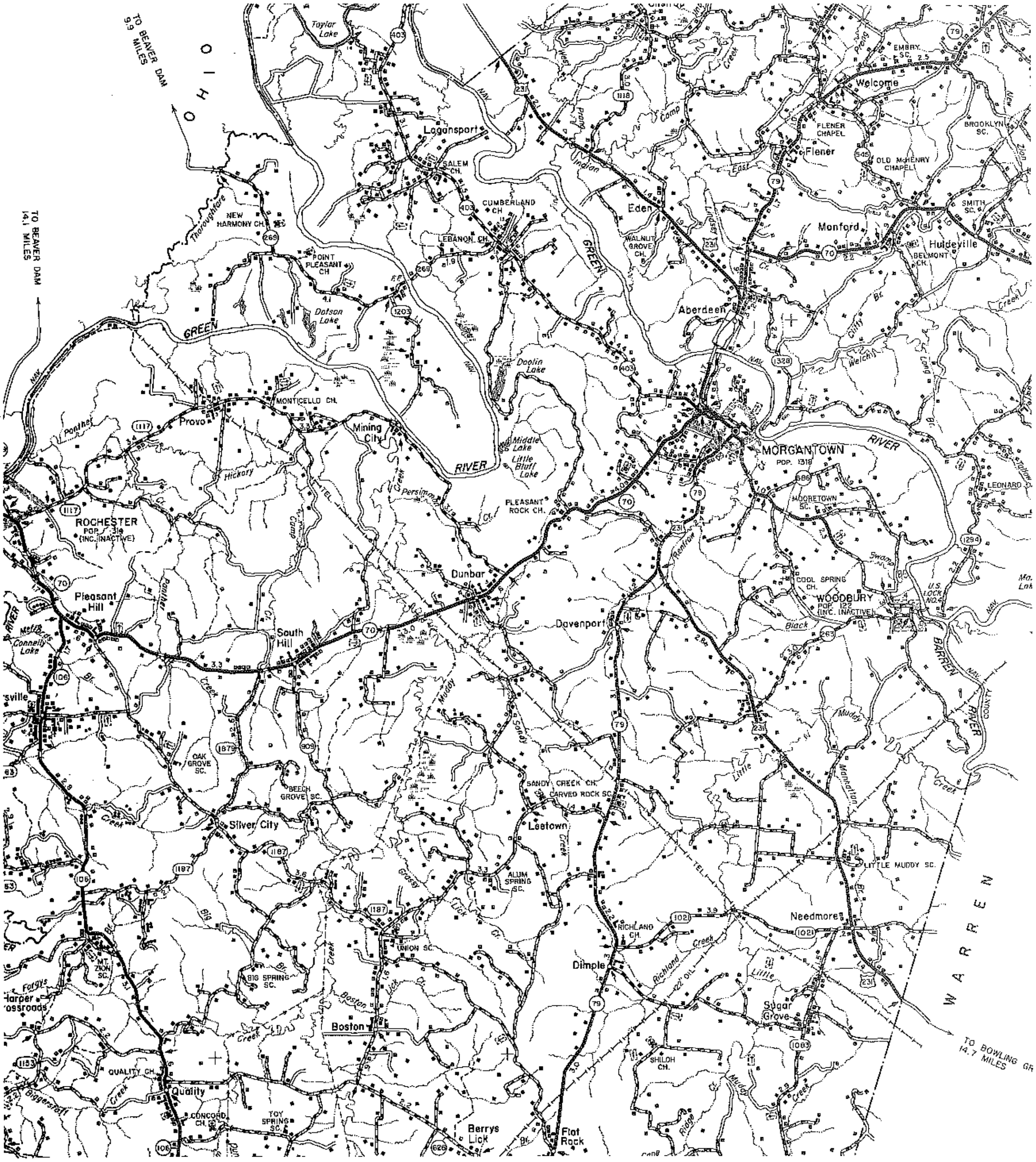

Fig. 1. The Silver City-South Hill (KY 1879) Road, Butler County.

Fig. 2. View of the Roadway at Station 1+00 (South End of Project).

Fig. 3. View of the Roadway at Station 142+00 (North End of Project).

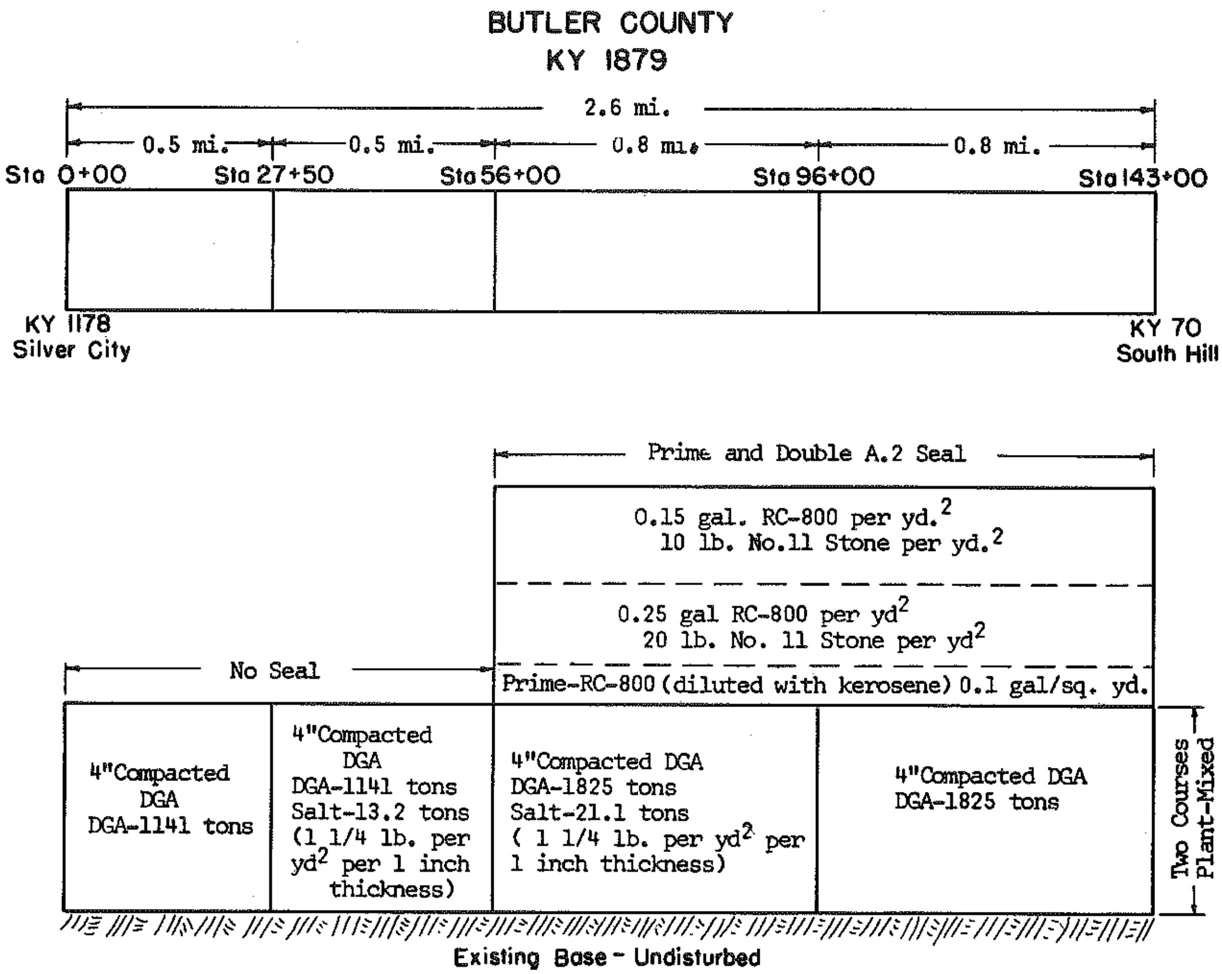

Fig. 4. Schematic Diagram of Experimental Base as Constructed.

salt used, was the usual material for snow and ice control and was purchased by Maintenance at a price of $16.70 per ton. All hauling and construction was performed by District Maintenance Forces.

CONSTRUCTION

Preparation of the Existing Roadway

Construction began on the project Monday, October 23, 1967. Inasmuch as the existing roadway cross section was good, reshaping of the roadway was limited to improving drainage of ditches in cut sections and to spreading loose floater stone uniformly across the surface. A patrol grader was used for this work. Tightly bound stone and the existing subgrade were not disturbed.

Plant Mixing of Dense Graded Aggregate

Plant mixing of the dense graded aggregate began Tuesday, October 24. Views of the DGA plant are shown in Figs. 5 and 6. Initially the DGA was from an existing stockpile but when this was depleted freshly crushed material was used. Gradations of the stockpile material and of the freshly crushed material are given in Table 1. Freshly crushed material was used for a portion of the salt treated section and for the northern control section.

It was planned to maintain the moisture content of the aggregate without salt at 6.7 percent and to increase the moisture content when salt was added. However, the moisture content varied considerably throughout the length of the project. In general the moisture content tended to run in excess of 6.7 percent. The water control on the plant, a single valve, was inadequate to maintain a constant moisture content, which varied, even though the valve setting remained constant. Fluctuations in moisture content appeared to be primarily influenced by the level of water in the storage tank. A tabulation of moisture content test results is contained in Table 2.

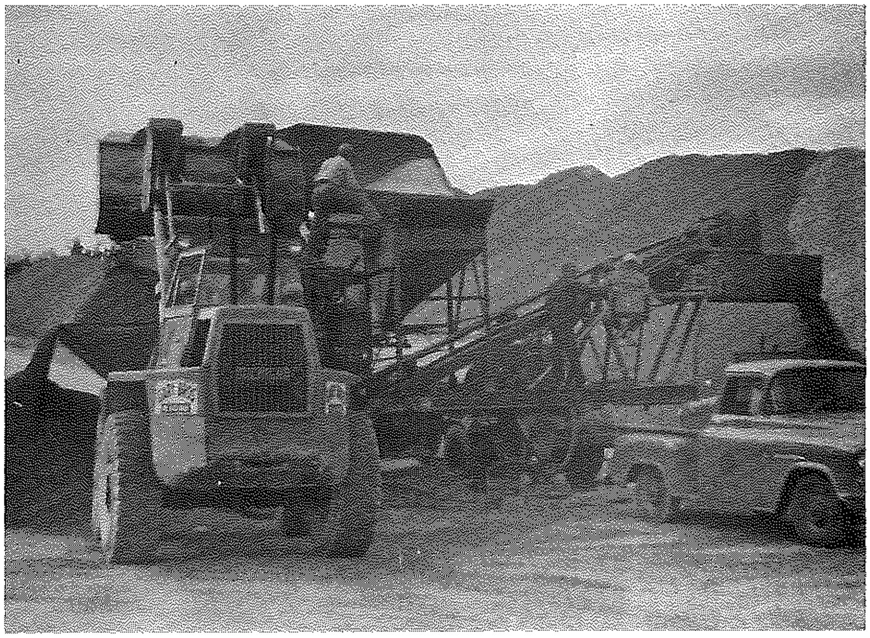

Fig. 5. An Overall View of the DGA Mixing Plant at the Gary Brothers Quarry. Basically the plant consists of an aggregate hopper, salt hopper, and pugmill. Water was stored in a truck transport tank.

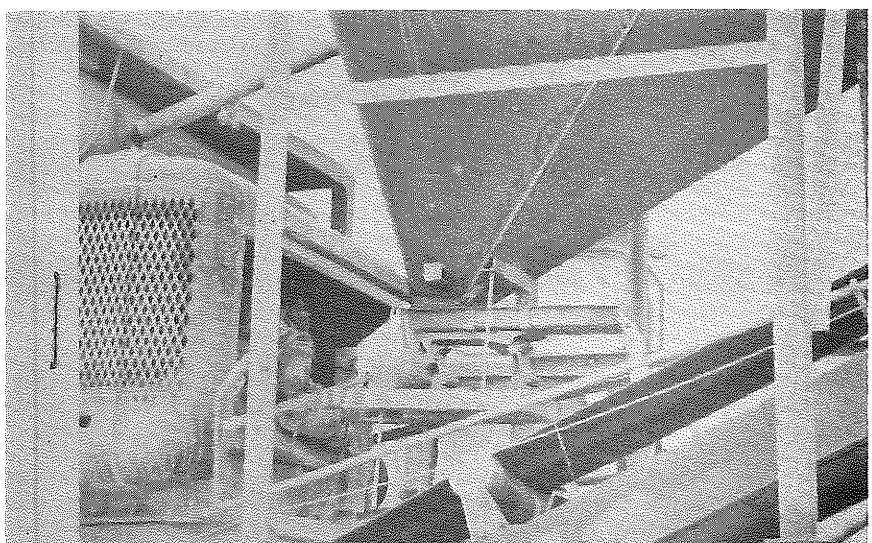

Fig. 6. A Close-up View of the Salt Hopper and Vibratory Apron-Type Feeder. The rate of salt feed is varied by the tilt on the apron and the rate of vibration. On this plant the vibrator was not operating properly and was capable on only one vibration rate.

Production of salt-treated material began mid day, Wednesday, October 25. The salt feeder was calibrated to deliver 23.2 pounds of salt per ton of dry aggregate. The aggregate feed rate was determined to be 142 pounds of dry aggregate per second from the net weight of a load and the time to produce the load. A moisture content of 6 percent was assumed in making this determination. Initially, the salt feed was calibrated to deliver 1.7 pounds per second. On succeeding checks, the salt tended to run slightly under this--generally around 1.5 pounds per second. On the last day, October 31, of running salt-treated material the feed rate was found to be 1.2 pounds per second. The salt appeared somewhat coarser and wetter than that used previously.

The salt was well distributed and intermixed through the aggregate. As previously noted, the water was poorly controlled by the plant; and, in general, the material appeared to contain excess water. It appeared that the moisture content was more than adequate to dissolve the salt. A check of moisture contents on samples from the left side and the right side of the same truck load indicated a difference of 2 percent between the two samples.

Placement and Compaction of Dense Graded Aggregate

Prior to placing any mix, the roadway was staked off on 100-foot stations, and stringlines were placed on both sides of the roadway, to a 16-foot width. The existing traffic-bound surface was wetted prior to placing any mix--to reduce loss of moisture from the mix. The mix was tailgated onto the roadway surface and excellent control of quantities was achieved by constant supervision of the distance covered by each load (Fig. 7). The material was applied and compacted in two lifts. The DGA base was constructed section by section, i.e. both lifts of base were constructed in a section before placing any mix in the next section.

A patrol grader was used to spread the mix over the surface (Fig. 8). Every effort was made to maintain a good crown for drainage. Good alignment and a sharply defined edge were achieved through use of the string lines and through use of an edger on the grader blade.

A pneumatic-tired roller and a steel wheel tandem roller were used to compact each lift of base (Fig. 9). Both rollers were kept moving at all times. In general it appeared that better compaction was achieved with the pneumatic-tired roller. At times, it was apparent that water contents in excess of optimum for compaction were being used as the compacted base was wet with a slurry of fine aggregate and water. The finished base was approximately 17 feet in width on the tangent sections and varied to greater widths on curves. Construction of the DGA base was completed November 3.

Construction of A-2 Seals

The compacted base was allowed to cure 24 days prior to priming, November 27, in preparation for sealing. Priming material consisted of 3 parts RC-800 and 2 parts kerosene and was applied to the roadway surface at a rate of 0.1 gallons per square yard. The northernmost 600-feet of the base were not primed at that time because the distributor did not carry sufficient material to finish the full distance. Inasmuch as weather was uncertain, it was decided to forego the remaining prime and to proceed with the placement of the seal. The prime was allowed to cure for two days prior to placing the seal.

On November 29, the first seal was placed and approximately 1/4 of the second seal was completed. No work was done on November 30 due to rain. The first seal consisted of 0.25 gallons per square yard of

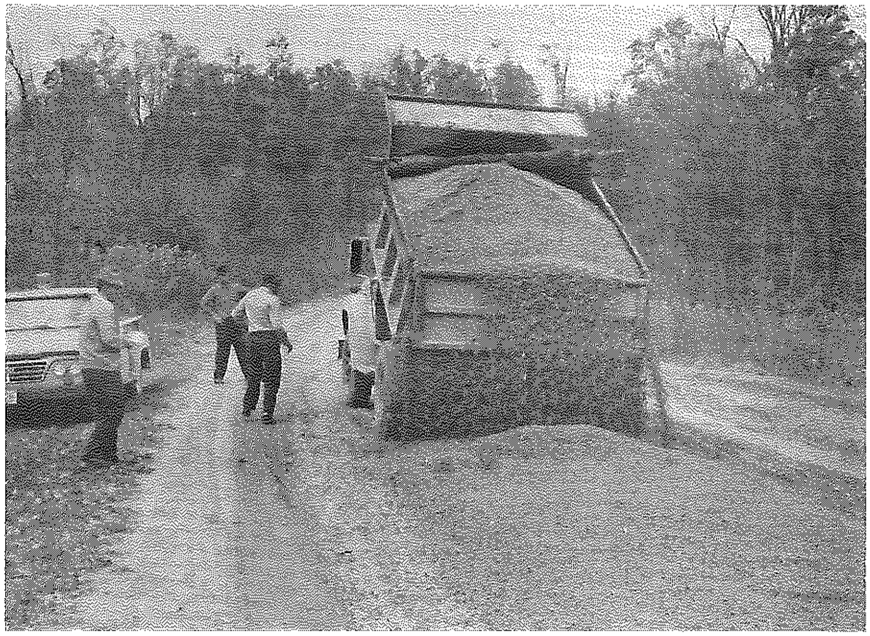

Fig. 7. The Aggregate was Spread on the Roadway by Tailgating the Aggregate Over the Proper Distance.

Fig. 8. The Material was Manipulated Across the Full 16-foot Width with a Patrol Grader. A sharply defined edge was gained by use of stringlines and a cut-off on the grader blade.

Fig. 9. Pneumatic-Tired and Steel-Wheeled Tandem Rollers Compacting DGA Base. The rollers were kept moving during the placing operations and good density was obtained.

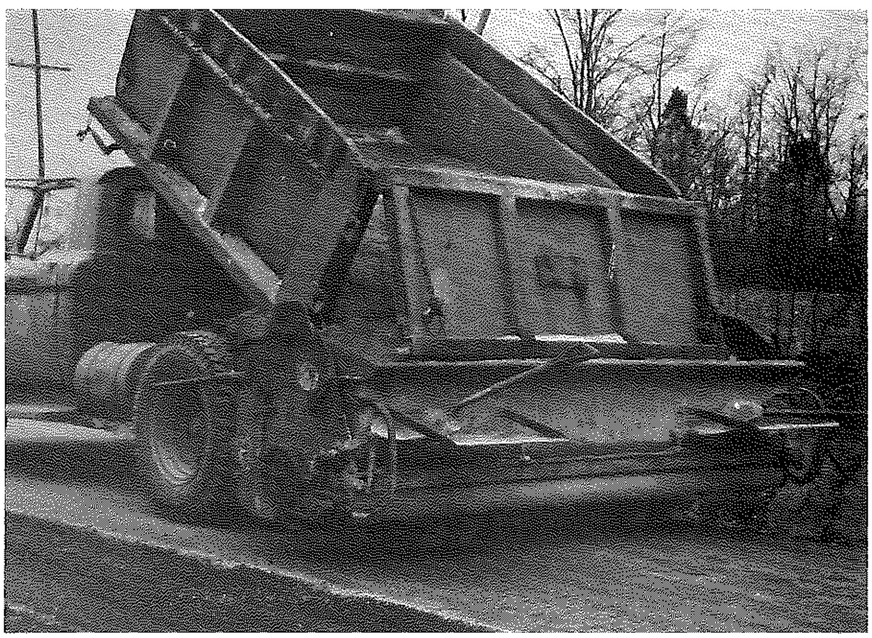

Fig. 10. Spreader Used to Apply Stone to Seal. The first seal has been placed in the far lane. The bituminous material, in the near lane, is the prime coat.

RC-800 covered with 20 pounds per square yard of No. 11 limestone (see Fig. 10). The second seal consisted of 0.15 gallons RC-800 and 10 pounds of No. 11 limestone per square yard. Uniform applications of all materials were obtained. The cover-stone was set into the seal with the pneumatic-tired roller. The seals were completed in early December.

INTERIM PERFORMANCE

Differences in performance between the salted and untreated sections became apparent during construction of the base. Within a few days after starting construction, it was apparent that stone was being abraded from the untreated material at a faster rate than from the salt-treated material (Figs, 11 through 16). This trend continued; and, at the time the seals were placed, the untreated material had much more loose (floater) stone on the surface than the salted material. The base underlying the loose (floater) stone still appeared dense and reasonably tight in the untreated section. There were numerous small, shallow, potholes throughout the entire length of roadway. The potholes appeared to be as prevalent in the salt-treated sections as in the untreated sections. The floater stone was not removed nor were the potholes repaired prior to sealing. The salt treatment preserved a better surface for the subsequent sealing operation.

Nuclear density and moisture tests were performed on the completed sections of base during construction and were repeated November 29, on the unsealed control section and the unsealed salted section. The results of these tests are summarized in Table 3. Much higher densities were indicated in the salt treated material. Average densities for the untreated and treated compacted base were 136.8 and 144.9 pounds per cubic foot respectively. The difference in these densities (8.1 pounds per cubic foot) is too great to be accounted for by the added weight of the salt alone. There are several variables such as surface texture, and chemical composition which affect nuclear density readings. The surface texture of the salt-treated material was smoother. It is believed that the density

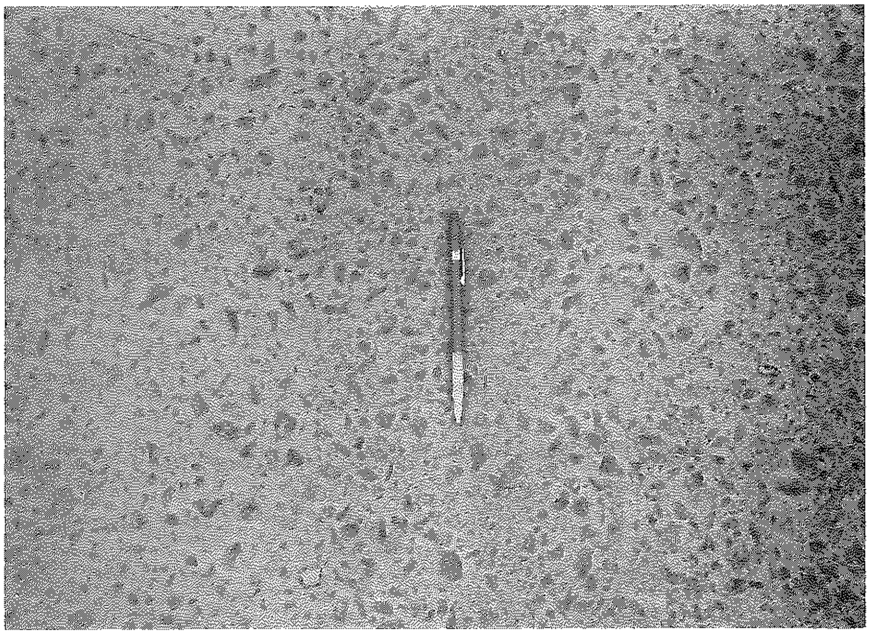

Fig. 11. Close-up View of the Salt-Treated, Unsealed, DGA Base November 29, 1967. The surface was tight and the recrystallized salt was apparent.

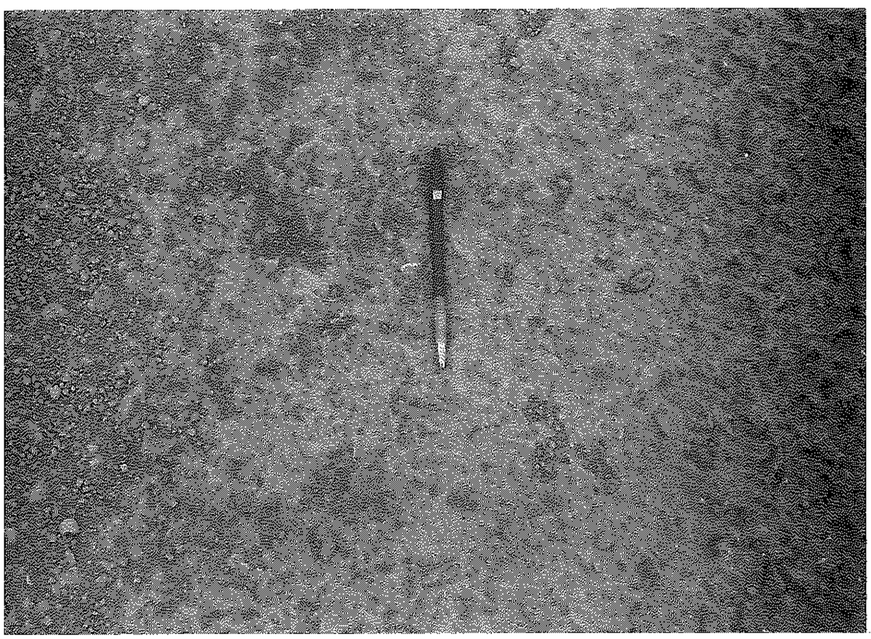

Fig. 12. Close-up View of the Untreated, Unsealed, DGA Base November 29, 1967. Note the loose stone (floater) and the aggregate particles beginning to break from the surface.

Fig. 13. An Overall View of the Salt-Treated, Unsealed, DGA Base, Station 38+00, November 29, 1967.

Fig. 14. An Overall View of the Untreated, Unsealed, DGA Base, Station 20+00, November 29, 1967. Note the large amount of loose stone from the base. The base, beneath the loose stone, was tight and dense.

Fig. 15. Salt-Treated and Sealed, DGA Base, Station 68+00, November 29, 1967.

Fig. 16. Untreated and Unsealed, DGA Base, Station 5+00, November 29, 1967

readings were influenced by the added salt and that future nuclear density measurements on this project should be performed by the "air gap" method which reportedly minimizes chemical affects. The density tests taken at the time of placing the seals indicated average densities of 132.1 and 140.7 pounds per cubic foot for the untreated and salt-treated base respectively. These data indicate a loss in density of approximately 4.5 pounds per cubic foot for both sections.

SUMMARY OF OBSERVATIONS

The comparative performance of the salt-treated and untreated, DGA material up until the placing of the double A-2 seals justify the following observations:

1. The salt treatment noticeably reduced the rate of erosion of aggregate from the DGA base and thereby preserved a tight, smooth surface for sealing.
2. Numerous small, shallow, potholes formed in all sections of the base. The potholes appeared to be as prevalent in the treated base as in the untreated base.
3. Good density was achieved on the project for both the salt treated and untreated base. The densities were uniform throughout the length of each section even though there was a considerable variation in moisture content of the mix during construction. The measured density of the salt-treated base was substantially higher than for the untreated base. Apparently the nuclear density measurements were influenced by the salt, but it is probable that the salt-treated material has a higher density. The density measurements also indicated that density was lost (approximately 4.5 pounds per cubic foot) in both the treated and untreated base during the curing interval (approximately 1 month) between construction and sealing. The moisture content readings did not indicate a significant difference in moisture retention by the treated and untreated material.
4. No construction problems were experienced in plant-mixing or laying the DGA with added salt. The salt was added with no

reduction in total plant production. It was necessary to have an additional high lift in order to charge the salt into the salt feed hopper. The exact rate of feed for the salt was difficult to maintain for the particular plant used on this project inasmuch as the vibrator on the salt feeder would only operate at one rate of vibration. No particular difficulty should be experienced in producing a uniform mix with a plant of the type used on the project if all control apparatus is in proper operating condition.

Evaluation of the long term effects of the salt in relation to aggregate retention on the unsealed sections will, of course, have to be relegated to some future date when further performance inspections can be performed. It is possible that some differences in retention of the A-2 seal on the treated and untreated material will appear. As noted previously, loose floater stone was not removed from the DGA base before sealing.

APPENDIX

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT, KENTUCKY

PROJECT AUTHORIZATION

OFFICIAL ORDER-AUTHORIZATION NO. 4783

It is hereby ordered that the project described herein be undertaken and accomplished.

PROJECT IDENTIFICATION

1. District	County	Route Number	Project Control Number
3	Butler	CR 1093	State - HF 16-1093A--C3 Federal -

2. Road System	Road Name	Program Item
County	Coal	CR 67-68

3. Project Description and Type of Work: Begins at Jct with KY 1187 at Silver City, extends North to Jct KY 70 near South Hill.

(See attached sheet)

4. Design Class	Traffic	Project Length
CL 6	Present 70 (Est.) Projected -	2.6 miles

RESPONSIBILITIES

5. Design	Right of Way	Title Deeded To
Not Required	County (Transferred to County by OO)	No deed required

6. Utility	Construction	Maintenance
County	Department of Highways State Personnel & Equipment	County

SOURCE OF FUNDS AND ESTIMATED COST

	Estimated Cost	Account Number	Fiscal Year
7. Design: None	---	---	---
8. Right of Way: County	None to Department	---	---
9. Utilities: County	None to Department	---	---
10. Construction: Dept. of Highways	$30,000	416	1967-68

11. Total Estimated Cost	Project Completion Date (month and year)
$30,000	June 1968

12. Remarks: This is an experimental project in which we will attempt to determine the merits of base stabilization with Sodium Chloride. Control sections and surface design are to be as shown on attached sheet.

PROJECT APPROVAL RECOMMENDED BY

John D. Ott
Signature

8/25/67
Date

SIGNED AND APPROVED

H. K. Sandusky JDO
Commissioner of Highways
or Designated Representative

8/25 1967
Date

LBR/pw

BUTLER COUNTY
KY 1879

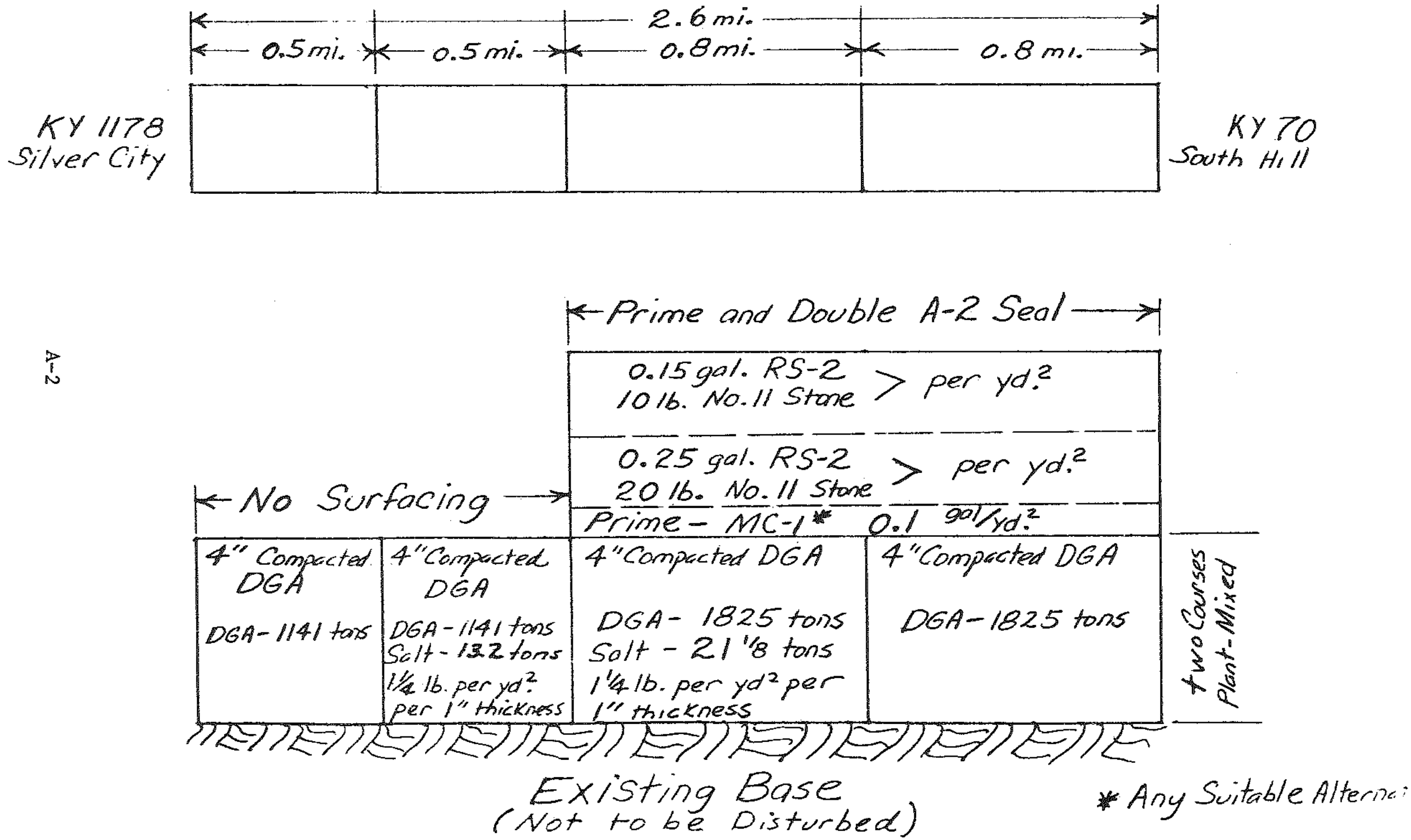

TABLE 1

TABULATION OF TEST RESULTS ON SAMPLED MATERIALS

Dense Graded Aggregate
Average Gradation

Sieve Size	Percent Passing	
	Stockpile	Fresh Crushed
1-inch	100	100
3/4-inch	99.3	100
3/8-inch	77.5	83.1
No. 4	53.4	62.8
No. 10	34.5	42.1
No. 40	16.4	16.1
No. 200	6.5	3.8

Specific Gravity and Absorption

Bulk Oven Dry	Bulk (S.S.D.)	Apparent	Absorption (%)
2.59	2.64	2.75	2.2

Salt (Sodium Chloride)
Gradation

Sieve Size	Percent Passing
3/8-inch	99.0
No. 4	61.4
No. 8	18.9
No. 30	1.3

Soil

Liquid Limit	24.9%
Plasticity Index	4.1%
Proctor, Standard	118.9 lbs. per cu. ft. at 12.8% optimum moisture
Specific Gravity	2.66
Soil Classification	
AASHO	A-4
Unified	CL-ML
CBR	17

TABLE 1

TABULATION OF TEST RESULTS ON SAMPLED MATERIALS
(Continued)

Mechanical Analysis

Sieve Size	Percent Passing
1-1/2 inch	100
1 inch	99.5
3/4 inch	98.2
3/8 inch	93.9
No. 4	91.4
No. 10	87.9
No. 40	82.1
No. 60	79.8
No. 200	62.6
.05 mm	46.0
.02 mm	29.5
.005 mm	13.0
.002 mm	10.0

TABLE 2

SUMMARY OF MOISTURE CONTENT DETERMINATIONS
ON UNCOMPACTED DGA

Date	Time	Location Sampled	Moisture Content (%)
10-24-67	A.M.	plant	7.6
	A.M.	plant	6.7
	A.M.	roadway	6.0
	A.M.	roadway	6.7
10-25-67	A.M.	plant	4.7
	A.M.	plant	6.8
	A.M.	roadway	5.9
	P.M.	plant	7.4
10-26-67	A.M.	plant	6.2
10-27-67	A.M.	plant	9.6
10-31-67	A.M.	plant	6.6
	P.M.	plant	9.5
	P.M.	plant	6.6
11-2 - 67	A.M.	plant	7.8
			5.8

Note--Moisture contents determined on 11-2-67 were both on the same load of mix. A sample taken on the left side of the truck, nearest the pugmill, gave a moisture content of 7.8 percent. The other moisture content was determined on a sample from the right side of the truck.

TABLE 3

SUMMARY OF NUCLEAR DENSITY AND MOISTURE DETERMINATIONS

Station	Lane	Dry Density (lbs./cu. ft.)	% Solid Vol. Density	Moisture Content (%)	Curing Time
		Measurements Taken During Construction of Base			
		Untreated Base			
1+00	N	130.7	80.9	4.4	5 hrs.
1+00	S	130.3	80.6	6.3	5 hrs.
1+00	N	134.6	83.3	3.6	2 days
6+00	N	138.0	85.4	3.2	2 days
12+00	S	132.7	82.1	4.4	2 days
18+00	S	142.5	88.2	3.5	2 days
24+00	N	136.4	84.4	4.5	9 days
Average		136.8	84.6		
		Salt-Treated Base			
30+00	N	145.4	90.0	3.2	7 days
30+00	C	145.2	89.9	3.1	7 days
36+00	C	141.7	87.7	3.8	7 days
42+00	N	146.2	90.5	3.3	7 days
48+00	N	145.3	89.9	3.2	7 days
54+00	S	149.4	92.5	3.1	7 days
60+00	S	142.1	87.9	4.2	4 days
66+00	N	144.9	89.7	4.0	4 days
72+00	N	143.4	88.7	4.5	3 days
78+00	N	146.4	90.6	4.2	3 days
		(open text)			
80+00	N	136.3	84.3	4.5	2 days
90+00	N	143.6	88.9	4.3	2 days
Average		144.9	89.7		
		Measurements Taken During Construction of Seal			
		Untreated Base			
1+00	N	131.9	81.6	2.0	1 month
6+00	N	134.8	83.4	1.6	1 month
12+00	S	129.6	80.2	2.5	1 month
Average		132.1	81.7	2.0	
		Salt-Treated Base			
30+00	N	139.0	86.0	2.2	1 month
30+00	C	139.1	86.1	2.4	1 month
36+00	N	141.4	87.5	2.7	1 month
42+00	N	143.4	88.7	2.4	1 month
Average		140.7	87.0	2.4	

Note--N, S, C refer to the north-bound lane, south-bound lane and centerline respectively.

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